take place, and perhaps also a redistribution of the stress due to the applied load. This alteration in the distribution of the internal stresses must be such as to cause the surrounding strong layers to stretch elastically as far as the weak material has been permanently stretched. The alteration in the internal stresses will remain after the applied load is removed, as the material which has been permanently deformed will be unable to relieve the stronger material. The apparent permanent set which is shown with quenched material after the removal of applied load, may thus be due to the real permanent extension only of the weak layers, and to the elastic extension of the strong layers produced by the new distribution of internal stresses. This explanation, however, does not suffice, at least in the case of iron and steel, to explain the behaviour of a quenched rod under applied stress, for Diagrams 2 and 3 show that such a rod may be stretched further than is compatible with elastic extension—even supposing some of the iron to have been overstrained to the maximum in the most favourable direction, without stretching nearly far enough for the yield-point of the iron to have been passed. Hence in the case of iron and steel recourse must be had to the explanations which simply attribute the observed effects to the formation of allotropic modifications of the metal or to the changes caused by the transition of the carbon—always present—from one condition to another.

In conclusion, it may be recorded that pieces of the iron and steel specimens used in this research were polished, etched, and examined under the microscope. In the case of the steel specimens the change from the ferrite and pearlite structure shown with the annealed material to the martensite structure shown with the quenched steel was very striking. But in the case of the Lowmoor iron no difference was detected by the microscope in the structures of the annealed and of the quenched specimens, although, as shown by Diagram 3, the elastic properties in the two conditions were vastly different.

"Harmonic Tidal Constants for certain Australian and Chinese Ports." By THOMAS WRIGHT, of the Nautical Almanac Office. Communicated by Professor G. H. DARWIN, F.R.S. Received August 1, 1902.

Ballina (New South Wales), Princess Royal Harbour (King George's Sound), Newcastle (New South Wales), Brisbane (Queensland), and Sydney (New South Wales).

The tidal observations made at these five ports have been reduced by the aid of certain sums placed at my service by the Government Grant Committee of the Royal Society, and I am indebted to Professor

G. H. Darwin for the loan of the apparatus he devised to facilitate the summation of hourly tidal heights, and to the Hydrographer, Admiral Sir W. J. L. Wharton, who supplied me with the observations. The whole of the observations were reduced by the methods devised by Professor G. H. Darwin.*

The observations made at the three first-mentioned ports were derived from copies of continuous diagrams made by automatic tide gauges; those at Brisbane and Sydney were times and heights of high and low water. The observations in every case extended over a period of about 1 year, and were almost complete. The breaks in the continuity of the observations were so short that approximate values could be easily inserted by interpolation with very small risk of error.

From the automatic records at Ballina, Princess Royal Harbour, and Newcastle the hourly heights were read off to the nearest one-tenth of a foot. The range of the tide at these ports is small, and an attempt was made to use a smaller unit, one-twentieth of a foot. An experiment with one month's observations showed, however, that the hourly and daily sums for the month differed very slightly, whether the readings were taken to the nearest one-twentieth foot or to the nearest one-tenth foot only. Besides, when the diagrams for two consecutive days were placed end to end there frequently appeared to be a difference of at least one-twentieth of a foot between the end of one day's curve and the beginning of the next day's. For these reasons it was considered to be sufficient to work to the nearest one-tenth of a foot, and that length was adopted as the unit.

The heights being read off, the method followed was exactly that described by Professor Darwin, except in one detail. The S sheet (that is, the sheet which is used for obtaining the hourly sums for the S tides) was not used. These sums were made on the sheets on which the hourly heights were entered from the diagrams. As in Professor Darwin's method, the hourly sums were made in groups of days which could be built up into the 30-days' period for the S tides and into the 74-days' period for the other tides. The *daily* sums were made throughout the year (they are required for the long-period tides). By forming totals of these *daily* and *hourly* sums in appropriate groups they act as a check on each other, and the two sets of sums are settled.

The hourly heights for the first 74 days were then entered on the strips, the strips were pinned to the M sheet, and the additions made. The total of the 48 sums was checked against a corresponding total made up from the *daily* sums and the *hourly* sums for S. Agreement among these three totals is a check upon the copying on to the strips, and also upon the sums for M. This slight modification of forming the sums for *S* from the original heights as read off from the diagrams saves one shifting of the strips, and, if all goes well and the totals

* 'Roy. Soc. Proc.,' vol. 48, pp. 277—340, and vol. 52, pp. 345—389.

agree, it seems hardly necessary to check the entering on the strips. In all other respects Professor Darwin's methods were followed exactly.

As already stated, the observations made at Brisbane and Sydney were the times and heights of high and low water. They were reduced by Professor Darwin's method. The observations were split up into four groups, each covering about one-fourth of a year. Each of these groups was separately reduced, and means of the four values of κ and H for each tide was taken as the final constant. These separate values form a check on the work independently of the systematic method of verification which was adopted in each stage of the computation. In the case of the more important tides, the agreement among the four values is very close. In the case of some of the smaller tides the differences are somewhat greater, but not great enough to make any serious difference in predictions based upon the constants.

The constants for the five ports are given, with others, below. The small value of H (0·159 foot) for M_2 at Princess Royal Harbour gave rise to the suspicion that there was some error in the work. This value is, however, borne out by the value of H for M_2 at Batavia (Java) given in the American Tide Table for 1900. Batavia is there quoted as a "Standard Port for Reference" for King George's Sound, and the height there given is 0·154 foot, or only 0·005 foot different from that obtained for Princess Royal Harbour. Careful examination of the work showed, too, that the value given below is correct.

Hong Kong, Swatow, Whampoa, Cooktown, and Cairn's Harbour.

The constants for these ports have been deduced at various times during the past few years. Except in the case of some of the Hong Kong tides, constants for these ports have not yet been published, and the present opportunity is taken to include them with the others.

The observations made at Hong Kong, Swatow, and Whampoa were from records by automatic gauges; those at Cooktown and Cairn's Harbour were observations of times and heights of high and low water. They were reduced by the same methods as the observations at the other five ports. The observations for the Chinese ports were kindly supplied by the Chinese Customs authorities; those for Cooktown and Cairn's Harbour by the Hydrographer. There seemed reason to suppose that the observations at Whampoa had not been very good, and the results for the tides S_6, R, M_1, M_6, L, μ, 2SM, J, Mf, and M_m seem to be so uncertain that I have thought it best to omit them from the Table of Values. For a like reason the L tide is omitted from the results for Cooktown and Cairn's Harbour.

	Princess Royal Harbour, King George's Sound. 1876—7.	Newcastle, N.S.W. 1900.	Ballina. 1898.	Hong Kong. 1889.	Swatow. 1897–8.	Whampoa. 1894–5.	Brisbane Bar. 1865–6.	Sydney. 1888.	Cooktown. 1890.	Cairn's Harbour. 1892–3.
Latitude......	35° 8′ S.	32° 57′ S.	28° 52′ S.	22° 18′ N.	23° 23′ N.	23° 5′ N.	27° 31′ S.	33° 52′ S.	15° 27′ S.	16° 55′ S.
Longitude ..	118° 0′ E.	151° 44′ E.	153° 33′ E.	114° 10′ E.	116° 39′ E.	113° 26′ E.	153° 0′ E.	151° 12′ E.	145° 15′ E.	145° 47′ E.
A_0	1·926	3·035	2·001	5·879	5·686	5·722	7·120	2·449	16·624	4·476
S_1 { H =	0·019	0·018	0·015	0·018	0·065	0·119	—	—	—	—
κ =	186	25	86	139	106	118	—	—	—	—
S_2 { H =	0·262	0·391	0·276	0·567	0·316	0·666	0·579	0·375	0·788	1·120
κ =	342	265	275	290	86	64	315	268	258	245
S_4 { H =	0·012	0·006	0·003	0·007	0·025	0·003	—	—	—	—
κ =	204	289	246	37	216	16	—	—	—	—
S_6 { H =	0·003	0·000	0·001	0·001	0·001	*	—	—	—	—
κ =	299	31	130	222	56	*	—	—	—	—
M_1 { H =	0·023	0·022	0·004	0·060	0·019	*	—	—	—	—
κ =	340	76	220	100	48	*	—	—	—	—
M_2 { H =	0·159	1·598	1·083	1·447	1·347	2·184	2·201	1·636	1·873	1·958
κ =	339	249	262	267	23	32	290	254	282	282
M_3 { H =	0·011	0·013	0·004	0·051	0·038	0·100	—	—	—	—
κ =	6	346	195	328	241	190	—	—	—	—
M_4 { H =	0·005	0·027	0·058	0·072	0·228	0·160	—	—	—	—
κ =	16	233	121	324	154	313	—	—	—	—

M_6	H =	0·002	0·018	0·025	0·017	0·053	*	—	—	—	—
	κ =	227	74	133	168	172	*	—	—	—	—
O	H =	0·417	0·289	0·310	0·949	0·765	0·815	0·325	0·337	0·299	0·407
	κ =	312	88	128	245	254	310	139	86	113	166
K_1	H =	0·623	0·513	0·454	1·191	0·941	1·068	0·592	0·419	0·287	0·872
	κ =	330	120	155	294	292	354	176	129	171	190
K_2	H =	0·074	0·127	0·072	0·134	0·119	0·288	0·158	0·102	0·215	0·305
	κ =	338	254	273	272	73	64	315	268	258	245
P	H =	0·172	0·153	0·139	0·388	0·269	0·351	0·196	0·139	0·096	0·290
	κ =	332	116	149	292	285	15	176	129	171	190
J	H =	0·037	0·035	0·031	0·032	0·025	*	—	—	—	—
	κ =	356	141	184	307	299	*	—	—	—	—
Q	H =	0·091	0·072	0·077	0·172	0·139	0·116	—	—	—	—
	κ =	291	165	103	228	242	326	—	—	—	—
L	H =	0·039	0·069	0·047	0·026	0·080	*	0·180	0·065	*	*
	κ =	349	238	286	284	34	*	258	237	*	*
N	H =	0·067	0·351	0·202	0·301	0·237	0·380	0·458	0·324	0·447	0·658
	κ =	17	235	254	255	358	16	288	250	239	269
ν	H =	0·020	0·123	0·018	0·012	0·074	0·047	—	—	—	—
	κ =	33	245	169	133	327	352	—	—	—	—
μ	H =	0·019	0·061	0·026	0·072	0·070	*	—	—	—	—
	κ =	16	226	335	237	176	*	—	—	—	—
R	H =	0·043	0·011	− 0·006	0·007	0·043	*	—	—	—	—
	κ =	192	213	347	60	180	*	—	—	—	—

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T { H =	0·038	0·024	0·016	0·035	0·015	0·036	—	—	—	—
T { κ =	255	291	270	281	82	23	—	—	—	—
MS { H =	0·015	0·062	0·043	0·067	0·103	0·144	—	—	—	—
MS { κ =	268	252	199	301	200	359	—	—	—	—
2SM { H =	0·027	0·026	0·037	0·026	0·025	*	—	—	—	—
2SM { κ =	71	236	213	235	91	*	—	—	—	—
Mm { H =	0·065	0·082	0·102	0·073	0·050	*	—	—	—	—
Mm { κ =	135	198	2	101	298	*	—	—	—	—
Mf { H =	0·064	0·051	0·097	0·083	0·069	*	—	—	—	—
Mf { κ =	175	105	314	310	120	*	—	—	—	—
Msf { H =	0·024	0·030	0·230	0·112	0·074	0·270	—	—	—	—
Msf { κ =	240	330	45	40	0	59	—	—	—	—
Sa { H =	0·328	0·232	0·413	0·466	0·467	0·484	0·109	0·093	0·346	0·202
Sa { κ =	111	70	7	243	270	171	8	16	320	9
Ssa { H =	0·235	0·074	0·063	0·280	0·258	0·135	0·005	0·008	0·051	0·050
Ssa { κ =	97	201	257	97	96	92	156	97	36	157

NOTE.—A — indicates that the values of these tides were not determined. An * indicates that there is reason to believe that the determination of the tides is so imperfect that it is better to neglect them.